Goal

- reduce the rate of aviation fatalities - by 80% in 10 years
  - by 90% in 25 years
- avoid increase in fatalities predicted with the doubling of operations

Aviation Safety

NASA teamed with the FAA, DoD and the aviation industry

- to advance aviation safety
- identified safety as NASA's top priority
- approved the formation of the Aviation Safety Program
- encouraged redirection of basic research to safety-related topics

Helicopter Safety

SAFOR >> improving the safety of civil *helicopter* operations.

analysed helicopter accidents and incidents

hosted workshop to identify problems and promising research topics

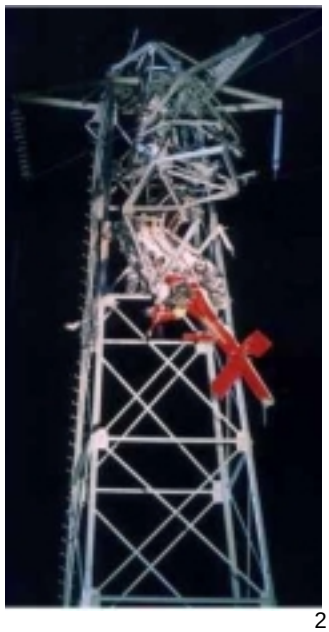
Team: NASA-Ames, other government agencies, industry and universities

Projects to Prevent Accidents

Safety through Flight Controls
- Control Designer's Unified Interface
- RIPTIDE
- RASCAL
- Design Guidance for IFR Certification
- Carefree Maneuvering
- Rotorcraft Unmanned Aerial Vehicles

Safety through Pilot Aiding
- Untethered Helmet Mounted Displays
- Hazard Alerting Displays
- Cockpit Display of Traffic Information

Safety through Pilot Training
- Course Of Action Training Tool
- Safety Website
- Autorotation training



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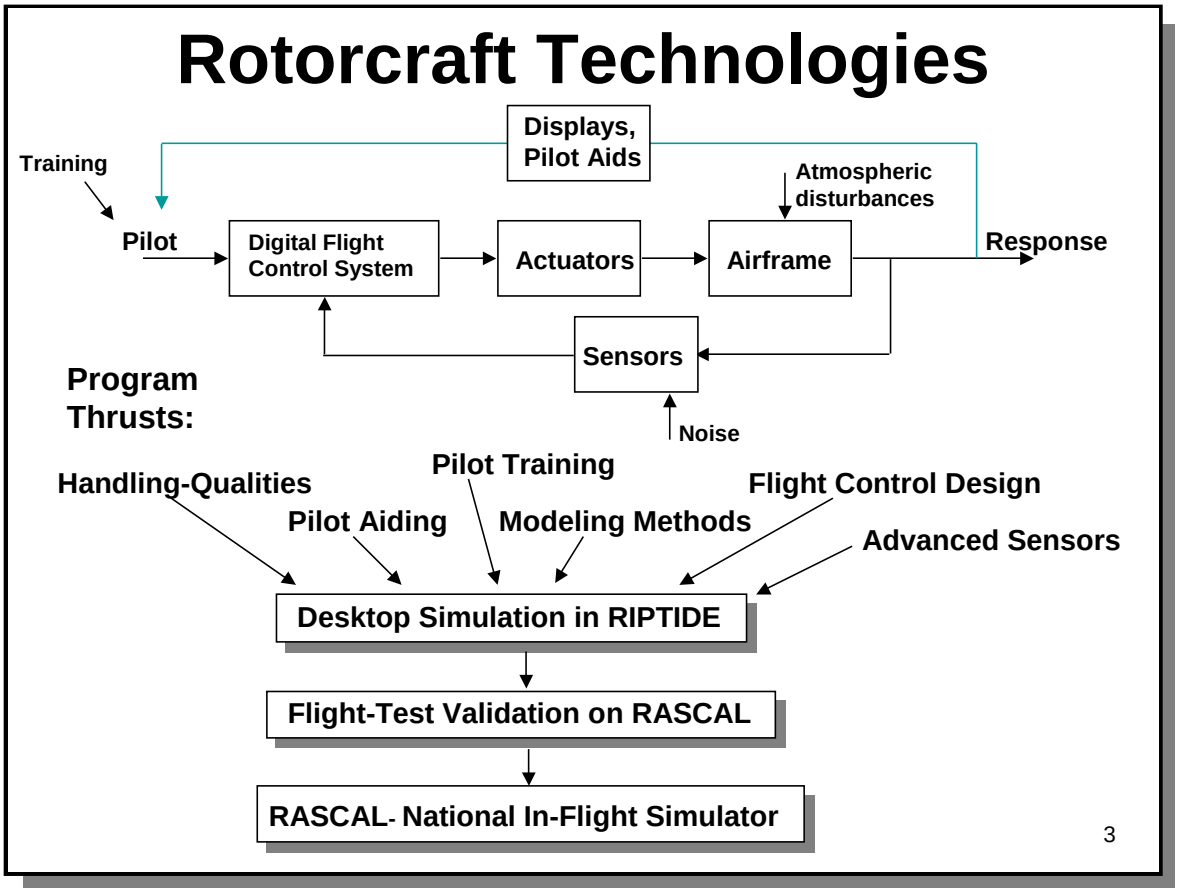
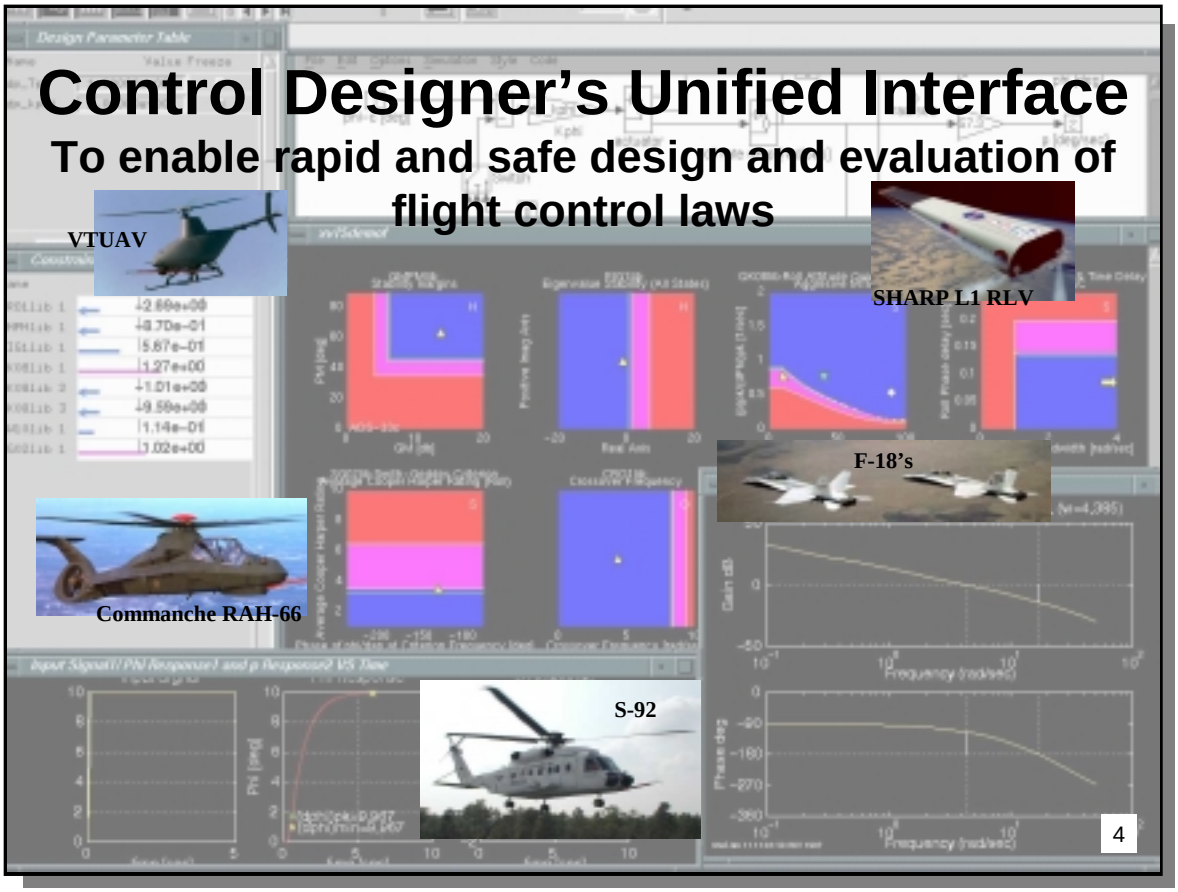
Approach

Perform accident analyses to determine why helicopters have accidents.

Safety through	**To address**	**By doing**
Flight controls	safe manuevering	control law design virtual flight testing RUAV control law development IFR operations
Pilot aiding	loss of situational awareness obstacle avoidance	cockpit display development pilot aid design
Pilot training	pilot error inexperience	safety awareness improvement training tools development



Handling-Qualities	Specifications, Flight test techniques Generic studies, Limited authority, Envelope limiting
Modeling Methods	Simulation validation/improvement Higher-order linear (FCS) models, System identification
Flight Control Design	Model following, Optimization Integrated design tools, Advanced rotor controls
Advanced Sensors	Display formats/dynamics, Blade motion sensors
Pilot Aiding	Cockpit displays, Tactile cueing
Pilot Training	Safety awareness, Physical & mental skill trainers
Desktop Simulation on RIPTIDE	Design and evaluation studies
Flight-Test Validation on RASCAL	System design validation studies Flight control and display laws / Perf. Validation
RASCAL- National In-Flight Simulator	Industry/government basic research, new systems evaluations



Goal

To enable rapid and safe design and evaluation of flight control laws.

Accomplishments to Date

- High level specifications can be easily implemented on CONDUIT to define fundamental actuator motions and controls.
- CONDUIT has been used to design flight control systems for the following manned vehicles: RAH-66 , HACT Demonstrator, Boeing JSF (X-32A), RASCAL, F14D - Block Upgrade, SH-2G (Kaman), Sikorsky S-92, F-18 (Dryden)
- CONDUIT has been used to design flight control systems for the following unmanned vehicles: Marine "BURRO" (KAMAN), Carnegie Melon University R-50 UAV, Microcraft 9" iStar, Navy VTUAV (Northrop-Grumman, Ryan Aeronautical), Sharp L1 RLV Demonstrator
- RASCAL just successfully completed a peer review (including participants from Dryden) of its safe in-flight concepts - might engage before workshop…

Future Plans / Opportunities

- Flight validation of CONDUIT-designed advanced control laws in RASCAL.
- Further development and design of control laws for other platforms

POC

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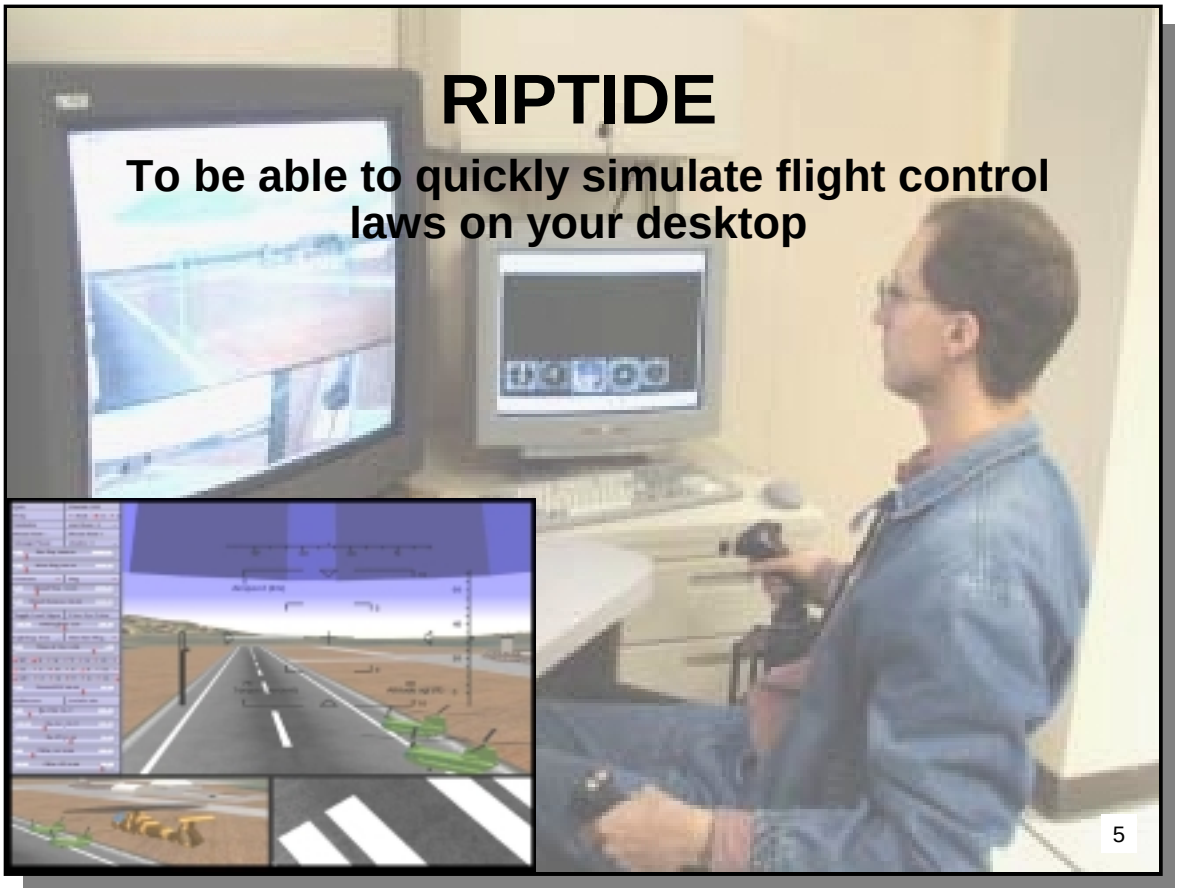

Goal

The goal of the Real-time Interactive Prototype Technology Integration/Development Environment (RIPTIDE) is to be able to quickly evaluate flight control laws on your desktop.

Accomplishments to Date

- Integrated existing tools for simulation, control system design/optimization, display law development
- Provided communication between them via shared memory so tools can function in conjunction with each other.
- Develop real time executive to control orderly operation of processes.
- Combined into high-fidelity, real time, engineer/pilot-in-the-loop rapid prototyping and evaluation environment. Specify configuration, flight condition, maneuver / mission, and environment.
- Transferred to Industry via Boeing and Wright Labs

Future Plans / Opportunities

- Improve simulation fidelity by improving visual system, tie in Head Mounted Display
- Develop and evaluate autonomous guidance and control algorithms
- Use PDA for waypoint navigation
- Perform piloted simulation of S-92 helicopter with CONDUIT designed control laws

POC

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Goal

The goal of the RASCAL (Rotorcraft Aircrew Systems Concepts Airborne Laboratory) helicopter is to provide a flying platform for safe evaluation of flight control and cockpit integration concepts.

Accomplishments to Date

- Laboratory has been created for investigation of new aeronautical systems, flight control and crew systems technologies
- Advanced instrumentation: carrier phase DGPS precision navigation, Health and Usage Monitoring System, and instrumentation for measuring both vehicle states and rotor states
- Research flight control system is C-language programmable, has full authority servos, and incorporates a fail-safe design concept
- Full in flight engagement of RASCAL's research flight control system took place August 31st

Future Plans / Opportunities

- Validation of high bandwidth control law display design
- Capture data for turbulence model development for civil helicopter flight control certification
- Test displays for terrain and traffic avoidance
- Support technology development for manned and unmanned air vehicles
- Innovative Flight Control Concepts - carefree maneuvering with active sidestick
- Rotor State Measurement & Feedback - use real time feedback for flight control

POC

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Goal

The goal of developing design guidance for civil helicopter IFR certification is to minimize civil helicopter accidents involving inadvertent flight into bad weather.

Accomplishments to Date

- Completed initial simulation to investigate civil helicopter IFR workload and to develop the basis for eventual certification methods and design guidance for civil helicopters.
- Civil Helicopter IFR Simulation Tool successfully developed for VMS.
- Initial results show that workload can be very high, especially in turbulence.
- Only the autopilot was consistently rated as low workload. More data is required to determine what is desirable, and what is safe enough.

Future Plans / Opportunities

- Obtain sufficient data to make initial estimates of rotorcraft dynamics/SAS/Autopilot for safe IFR operations
- Assess the effect of SAS failures

POC

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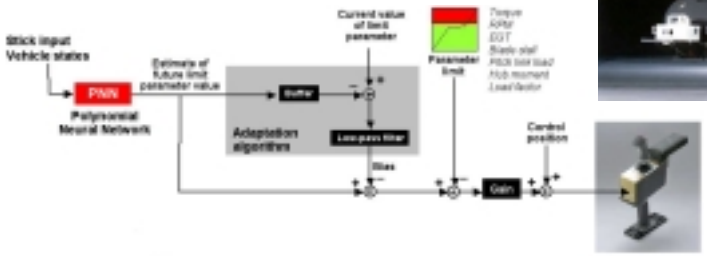
Carefree maneuvering

To allow the pilot to extract the full capability of the aircraft safely without exceeding limits



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Goal

The goal of carefree maneuvering is to allot the pilot to extract the full capability of the aircraft safely without exceeding limits.

Accomplishments to Date

- Several simulations conducted - two-axis sticks tested in VMS
- Reduction of envelope exceedence was successful
- Three-axis stick developed for RASCAL - NASA SBIR-funded, $600k, 3 yr.
- RASCAL Installation and Testing -HUMS installation, Flight testing of digital sensors
- Design and test of Bell 412 tactile cueing system
- NRC/CDF flight test, NASA Ames Director co-funded, $180k, 18 mo.

Future Plans / Opportunities

- Integration of three-axis stick into RASCAL
- RASCAL Installation and Testing - Data gathering using HUMS installation
- Flight testing of digital sensors, Test of SDI exceedance in future plans
- Continued support of Bell 412 effort at NRC
- HACT - Initiation of Phase 2 flight demonstration effort

POC

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Goal

To reduce the time and cost of a Rotorcraft Unmanned Autonomous Vehicle (RUAV) flight control system development effort and achieve satisfactory handling-qualities.

Accomplishments to Date

- Developed a seamless interface between design an optimization tool, a desktop simulation tool and external simulation models.
- Demonstrate control law optimization and simulation of 9” diameter ducted-fan UAV
- Flight test validation of new RUAV tools
- Cooperative Research Development Agreement to support DARPA OAV (FCS) with Honeywell/AeroVironment

Future Plans / Opportunities

- Other RUAV research applications in 2000/2001: VTUAV (Navy/Northrop), Burro (Kaman), R-50 (CMU)
- Address key technical challenges: RUAV specific sensors and controls, dynamic response
- Design requirements for UAV mission, integration of RUAV design tools

POC

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Goal

The goal of developing an untethered head mounted display is to improve pilot –vehicle performance through better situational awareness.

Accomplishments to Date

- A light weight, low power, untethered HMD has been selected as an appropriate candidate for this project.
- This HMD has been integrated into the RIPTIDE research simulator environment.

Future Plans / Opportunities

- Determine performance limits with respect to reconstruction of a motion signal
- Develop embedded algorithms for signal up-sampling and decoding

POC

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Goal

The goal of the hazard alerting displays work is to help pilots avoid hitting things. This display helps cropduster pilots avoid wires.

Accomplishments to Date

- Interviews were conducted with agricultural applicators to understand the complex nature of this pervasive problem.
- Based on these interview, an appropriate wire alert was developed.
- A simulation has been conducted to test the effectiveness of wire alerting.
- Analysis of the data has shown that wire alerts can reduce strikes and improve consistency of performance.

Future Plans / Opportunities

- Simulation of avoiding unseen wires for greater realism.
- Tactile cueing (steering cue & hazard alert) in seat back (with U.W.Florida)
- Demonstration to Trimble.

POC

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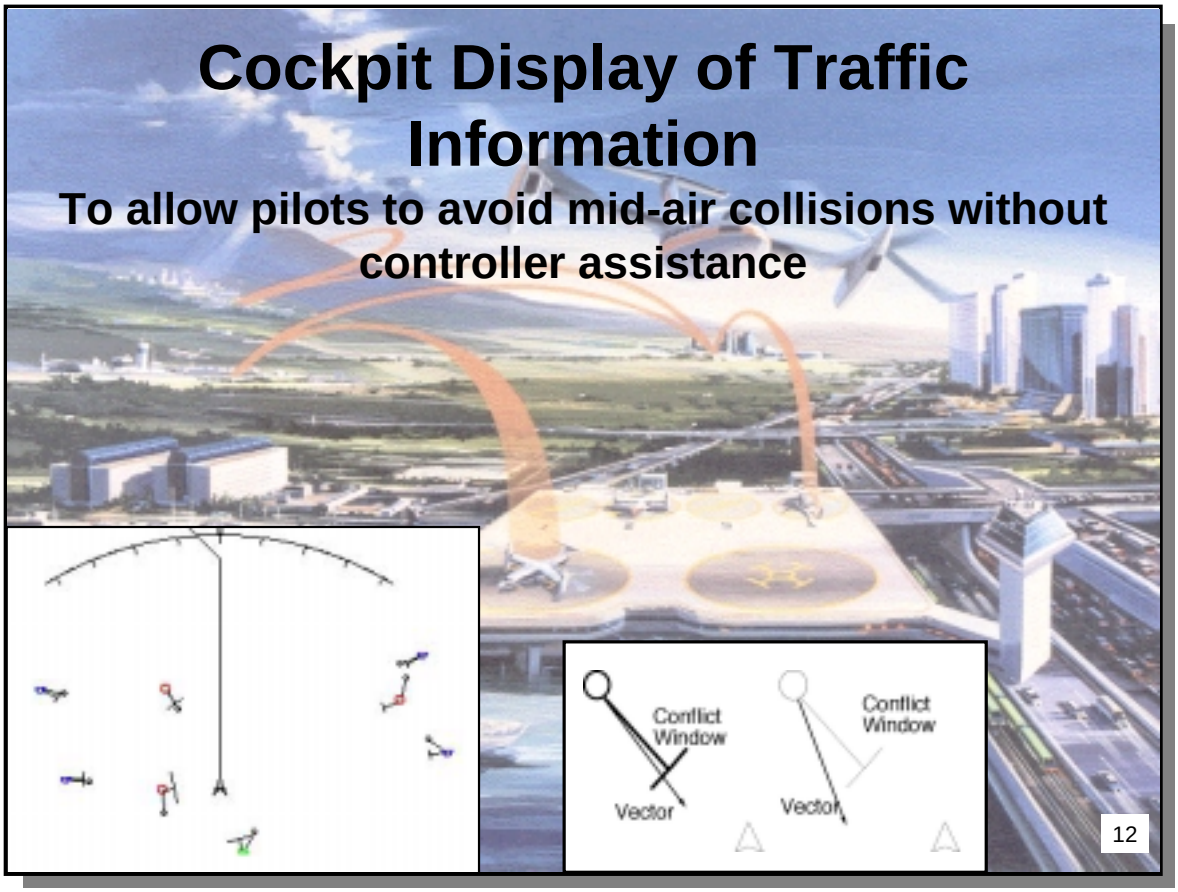

Goal

The goal of Cockpit Display of Traffic Information work is to allow pilots to avoid mid-air collisions without controller assistance.

Accomplishments to Date

- Developed the display concept for traffic avoidance with multiple variations.
- Conducted a simulation which tested four display configurations in non-real-time laboratory task.
- Analysis of data indicates that one configuration is particularly helpful in assisting identification of potential mid-air collisions.

Future Plans / Opportunities

- Simulate and evaluate the displays in identifying multiple conflicts.
- Simulate flight with conflict detection.

POC

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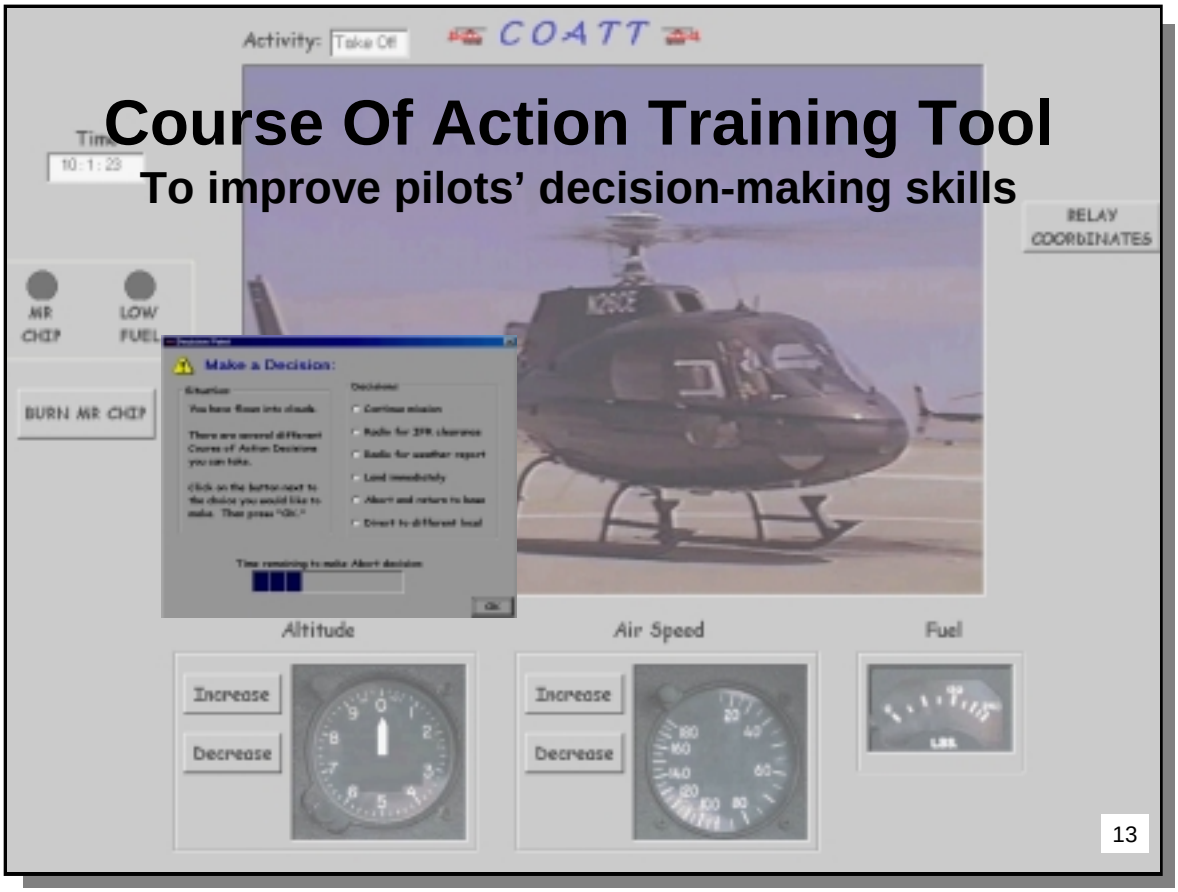

Goal

This Course of Action Training Tool is designed to improve pilots' decision-making skills and reduce the number of accidents due to pilot error and inexperience.

Accomplishments to Date

- Typical emergency medical transport (EMT) mission scenarios were defined
- A decision network was developed including nodes for the environment, aircraft states, and external events.
- A prototype, low-cost decision trainer was developed which integrates computer simulation, full motion video, still photographs, and audio.
- The prototype is undergoing field evaluation.

Future Plans / Opportunities

- Incorporate improvements based on feedback from field test.
- Transition to web based trainer.
- Expand training application to other missions.

POC

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Goal

The goal of the NASA helicopter safety web site is to reduce the accident rate by giving pilots a one-stop shop for helicopter safety information.

Accomplishments to Date

- The accident analyses are complete and have been published.
- The NASA Helicopter Safety Web Site “safecopter” has been posted
- Columns: updates from the FAA, reprints of Rotor & Wing articles, Aviation Safety Reporting System articles, “autorotation” articles, Bell’s Heliprops, accident summaries and statistics.
- Provides information on safety aids and a list of links to other safety minded helicopter websites.
- The website is receiving hits from ~2000 sites per month.

Future Plans / Opportunities

- Add an economic analysis of an accident, more mission specific information, training and maintenance sections.
- Add searchable databases for accidents and safety articles.
- Develop interactive illustrations of potentially risky maneuvers, vehicle states, & failures.

POC

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Goal

The goal of the autorotation training task is to reduce the autorotation accident rate through simulation.

Accomplishments to Date

- A simulation was conducted to examine the fidelity requirements of motion and the contributions of texture and grid upon successful autorotation performance.
- The critical cues of attitude, horizontal speed, and vertical speed were measured objectively and subjectively.
- The simulation produced some distinct differences between the conditions which will feed into recommendations for an autorotation simulator.

Future Plans / Opportunities

- Develop a head up display for autorotation training.
- Conduct a VMS experiment using R-22 model, integrating best ideas to date.
- Perform transfer of training study.

POC

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SAFOR Status

TASKS			
Item	Funding Source	Status	Continuation actions
Safety through Flight Controls			
Control Designer's Unified Interface	**NASA/ Army**	**Nearly complete**	**Army - partial**
RIPTIDE	**NASA/ Army**	**Complete**	**Army - partial**
RASCAL	**NASA/ AvSP**	**Engagement imminent**	
Carefree Maneuvering	NASA	**Ongoing**	**Army - partial** **RASCAL flts not included**
Design Guidance for IFR Certification	NASA	**Ongoing**	
Rotorcraft Unmanned Aerial Vehicles	NASA/ Industry	**Ongoing**	**Industry, Army - partial** **NASA - Intelligent Systems**
Safety through Pilot Aiding			
Untethered Helmet Mounted Displays	DARPA/NASA	**Ongoing**	**DARPA**
Hazard Alerting Displays	NASA	**Ongoing**	**Army**
Cockpit Display of Traffic Information	NASA	**Ongoing**	
Safety through Pilot Training			
Course Of Action Training Tool	NASA	Phase 1 complete	
Safety Website	NASA	Phase 1 complete	
Autorotation training	NASA	**Ongoing**	